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The views expressed are those of the author and do not represent the official views of the corporation.

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A Report Prepared for

CANADA MORTGAGE AND HOUSING CORPORATION

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Summary

Failure has occurred in concrete foundations of housing constructed in Atlantic Canada during the 1980's. Cracks in basement walls and settling of concrete basement floor slabs has resulted in ground and rain water entering the basements of the newly constructed housing. This water has damaged the finished walls of the interior of the basement. Most home owners utilize the basement area of their homes for recreational rooms and additional living space. They insulate and gyprock the walls. There has been damage also to floor carpets and finished flooring. Home owners have been inconvenienced and are upset about the lack of concern shown by many contractors. From a list of over three hundred candidate troubled units, thirty units were selected for detailed study. The results from this study illustrates some of the errors made by the construction industry. Guides to rectify some of the errors are offered. The information gathered was compiled from an inspection and analysis of the thirty housing units located in the Halifax, Dartmouth, Sackville and Bedford areas of the Province of Nova Scotia. The inspections did not reveal any poor concrete nor major quality differences which might be associated with concrete cracking.

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1. INTRODUCTION

During the 1980's the author carried out, as part of his professional practice, a number of house inspections in the Halifax, Dartmouth, Sackville and Bedford areas of Nova Scotia. It became apparent during this work that a substantial number of newly constructed houses were experiencing cracking of the concrete foundation walls and the settling of the interior load bearing concrete basement floors at the location of columns and partition walls. The damage usually became apparent and the defects found to be important to the owner when water entered the basement and caused minor or major problems.

Owners complained to the author that the contractors who built their houses should be responsible for the repairs and the damage. The author decided there might be a problem with the on going construction of houses in the area and requested assistance from Canada Mortgage and Housing Corporation to study the problem. If the results were significant, they would be shared with industry and other researchers, through the Canada Mortgage and Housing Corporation External Research Program and perhaps point the way for housing contractors to improve their choices of construction materials and their on-site practices.

The Corporation granted the funds for the study in 1988.

2. PROCEDURE

The objective of the research was to study, by site inspection, a number of reported problem housing units in the Halifax, Dartmouth, Sackville and Bedford areas of Nova Scotia. Candidate troubled housing units were made available by:

i) the Atlantic New Home Warranty Corporation;

ii) the Department of Housing, Province of Nova Scotia; and,

iii) Professional Project Engineering Limited.

The basis of the research was to be data from the troubled units having water intrusions or structural problems due to cracking of the concrete foundation walls and/or basement floor slab. Attempts were to be made to determine:

1. what caused the problem,
2. what had been the type and cost of the remedy,
3. how effective had been the repairs; and
4. what steps could be taken during construction to limit and control cracking and prevent water and foundation damage.

The units selected for further study and analysis were chosen from the files of three sources: the Atalntic New Home Warranty Corporation; the Department of Housing of the Province of Nova Scotia; and Professional Project Engineering Limited.

Details concerning the files of these sources are as follows:

i) The 1984-1988 records of the Atlantic New Home Warranty Corporation had over 200 housing units (single and duplex) which reported home owner complaints of structural and/or basement failure. A large number of these resulted from cracks in the concrete foundations and/or basement slabs.

ii) The 1980-1987 files of the Department of Housing of the Province of Nova Scotia for the Halifax, Dartmouth, Sackville and Bedford areas listed 109 family units (single, duplex or row housing). Since no complaint data was readily accessable, the author made site visits to all the family units to find out how many had cracks in the foundations and basement slabs. Detailed inspections were carried out on units which had cracks. For comparison, some units were also included which had no cracks (see E-15,16,17,28,29 and 30). These units illustrate new homes are being constructed that do not have cracks in foundation walls.

iii) The 1981-1988 home inspection files of Professional Project Engineering Limited were searched and a number of possible candidates were set aside as provisional candidates.

The final selection of candidates to be included in the thirty candidate survey was based on the following criteria:

i) owner's cooperation,

ii) accessibility and estimated time required for inspection,

iii) severity of problems, and

iv) availability of information .

From all the sources, the Atlantic New Home Warranty Corporation, the Department of Housing of Province of Nova Scotia and files of Professional Project Engineering Limited, the thirty candidates were selected for site inspections and/or detailed reporting. With the co-operation of the home or property owners, three of these sites had excavations made at the exterior of the concrete walls where the cracks occurred and one had part of the basement slab removed to view the underside of the slab. Part of the gyprock of the interior wall of several candidates was removed prior to their inspection, making further analysis possible.

To ensure uniformity of reporting and to assist in the subsequent data analysis, two reporting sheets were prepared and used:

i) an Owner's Questionnaire, and

ii) a Field Inspection Report.

Information on these two reporting sheets was collected by completion of the sheets by the owner and the Researcher before analysis. The Owner's Questionnaire asked the following questions: the name and address of owner; 1st, 2nd or other owner; where and when cracks noticed; description of the repairs; awareness by owner of any details concerning construction, such as, when walls were poured and did the home have drain tile around perimeter or gyprock and insulation on interior of the basement walls.

Field Inspection Reports were completed by the Researcher and contained all or some of the following items of information:

i) perimeter dimensions of the home,

ii) type of unit (single, duplex or row housing),

iii) roof drain to ground or to tile,

iv) splash block provided for eavestrough downpipe,

v) grade to or from foundation walls

vi) original or fill soil near foundation wall,

vii) original or fill soil near or under footings,

viii) distance footings below grade,

ix) size of footings,

x) thickness of foundation wall,

xi) thickness of basement slab and cracks if any,

xii) location and size of cracks in foundation walls,

xiii) from site visit was any reinforcing steel visible,

xiv) was reinforcement called for in specifications,

xv) appearance of concrete,

xvi) gyprock & insulation on interior wall,

xvii) dampproofing and/or waterproofing of walls,

xviii) tile & crushed stone located or specified,

xix) distance top of wall to basement slab,

xx) vapor barrier under slab & slab thickness,

xxi) slab concrete tight to wall or joint left,

xxii) floor slab on top of footing,

xxiii) control joints in wall or slab,

xxiv) sill plate nailed or bolted to wall,

xxv) description & cost of damage & crack repair.

xxvi) water present on site visit,

xxvii) did basement slab support load bearing partitions or columns.

All of the candidates selected for the home survey, were mailed the Owner's Questionnaire along with a letter outlining the nature of the study and soliciting support and approval to be included in the study and an offer of a free house inspection for their trouble. Twelve home owners agreed to be used as candidates from three dozen mailed enquiries. Some of these were included in the thirty candidate survey and the remaining needed to make up thirty samples were selected from file information available from the source records noted above. All the sample candidates included in the study were or had been visited by the researcher and/or were revisited to clear up any points. The Researcher inspected seventy-five other site from the files of the Housing Department of Province of Nova Scotia. These were not included in the survey as they showed no sign of failure of foundation walls or basement floor slabs.

All information provided in the Owner's Questionnaires and the Field Inspection Reports was computer filed. The Appendix to this study provides Tables 1. and 2. which summarize the Owner Questionnaires and the Field Reports.

3. RESULTS

The data from the thirty units inspected in this study were analysed and reviewed together with the data from failures of other housing which were previously reviewed but not included in this study. The findings of the research are as follows:

i) The cause of cracks in foundation walls can be broken down into 2 categories, namely; structural and shrinkage. The structural cause arose when the foundation walls did not have enough frost cover and/or frost heave took place due to adhesion. A crack resulted from uplift and undirected water entered. The shrinkage problem came into play when walls simply developed a shrinkage crack in early life of walls and undirected water eventually found its way into the home. (See Table 1.)

ii) Cracks in basement floors were not unusual. No candidates used control joints. Basement floors which had severe cracking, were the result of settling of soil under the slab. Major damage occurred if the slabs supported loaded partition walls or columns.

iii) The repair remedy was major when basement slabs failed or there was severe wall failure. Most wall repairs were effected by filling in the cracks with cement or chemical grout. Major damage repairs necessitated rebuilding walls and slabs. The repair cost varied from $ 450 to $ 3132; the damage cost from $ 190 to $ 8000.

iv) In some cases the wall repairs have been effective, while in others the cracks have opened again. Major damage repairs have held up to date.

4. RECOMMENDATIONS

The steps that should be taken to limit and control cracking and prevent water and foundation damage are as follows:

i) Make sure frost coverage upon completion of the rough grading is at least 48 inches around perimeter exterior footings.

ii) In study area, include working drain tile around the perimeter of all exterior foundations.

iii) Make sure all finished grades slope down and away from foundation walls.

iv) Connect roof leaders to tile or include rain splash blocks.

v) Include reinforcing steel in exterior foundation walls and welded wire mesh in basement floor slabs.

vi) Use control joints in walls and slabs when possible and do not pour slabs tight to foundation walls, i.e. use a flexible joint between the slab and the interior face of the concrete foundation wall.

vii) Do not place basement floor slabs directly on top of the footings.

viii) Compact fill under basement slabs, especially if slab is to carry loaded partitions and/or columns.

Note: In the area of Halifax, Dartmouth, Bedford and Sackville, Nova Scotia, the National Building Code of Canada applies to housing construction. All units inspected, more or less, met with the minimum requirements outlined in the code with reference to the concrete foundations. No exhaustive inspection of each unit was made. The contractors tend to build as close to the minimum requirement as possible to keep cost of building unit to minimum.

APPENDIX

FAILURE OF CONCRETE FOUNDATIONS IN ATLANTIC CANADA HOUSING CONSTRUCTED IN 1980'S

TABLE 1 OF RESULTS

	CANDIDATE NUMBER	WALL CRACKED	WATER ENTERED	FOOTING BELOW GRADE	DRAIN TILE SPECIFIED OR LOCATED	GRADE NEAR CRACK
!	E-1	YES	YES	3'-9"	NO	LEVEL
!	E-2	YES	YES	4'-9"	NO	LEVEL
*	E-3	YES	YES	3'-9"	YES	TOWARD WALL
!	E-4	YES	YES	4'-4"	NO	LEVEL
*	E-5	YES	YES	5'-9"	NO	LEVEL
!	E-6	YES	YES	8'&3'	NO	LEVEL
^	E-7	YES	YES	8'&5'	YES	LEVEL
*	E-8	YES	YES	4'-2"	NO	LEVEL
*	E-9	YES	YES	3'-11"	NO	LEVEL
!	E-10	YES	YES	6'-1"	NO	TOWARD WALL
*	E-11	YES	YES	2'-4"	NO	TOWARD WALL
*	E-12	YES	YES	3'-0"	YES	LEVEL
!	E-13	YES	YES	4"11"	NO	LEVEL
*	E-14	YES	YES	U	NO	TOWARD WALL
	E-15	NO	NO	4'-0"	YES	AWAY FROM WALL
	E-16	NO	NO	5'-8"	YES	AWAY FROM WALL
	E-17	NO	NO	4'-8"	YES	AWAY FROM WALL
!	E-18	YES	NO	4'-0"	YES	AWAY FROM WALL
!	E-19	YES	NO	3'-10"	YES	AWAY FROM WALL
!	E-20	YES	NO	3'-10"	YES	AWAY FROM WALL
!	E-21	YES	NO	3'-10"	YES	AWAY FROM WALL
!	E-22	YES	NO	4'-0"	YES	AWAY FROM WALL
!	E-23	YES	NO	4'-0"	YES	AWAY FROM WALL
!	E-24	YES	NO	4'-0"	YES	AWAY FROM WALL
!	E-25	YES	NO	4'-0"	YES	AWAY FROM WALL
!	E-26	YES	NO	4'-0"	YES	AWAY FROM WALL
!	E-27	YES	NO	4'-0"	YES	AWAY FROM WALL
	E-28	NO	NO	4'-0"	YES	AWAY FROM WALL
	E-29	NO	NO	4'-0"	YES	AWAY FROM WALL
	E-30	NO	NO	4'-0"	YES	AWAY FROM WALL

NOTE: U = UNKNOWN
! = SHRINKAGE CRACK
* = STRUCTURAL CRACK CAUSED BY FROST DAMAGE
^ = SLAB FAILURE CAUSED BY INADEQUATE COMPACTION

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TABLE 2 OF RESULTS

CANDIDATE NUMBER	JOINT AT WALL	SLAB RESTING ON FOOTING	ROOF DRAIN TO GROUND	TILE	SPLASH BLOCK	REPAIR COST	DAMAGE COST
E-1	NO	YES	YES		NO	N/A	N/A
E-2	NO	U	YES		NO	N/A	N/A
E-3	NO	YES	YES		NO	$495	$296
E-4	NO	U	YES		NO	U	U
E-5	NO	U	YES		NO	N/A	U
E-6	NO	U	YES		NO	U	U
E-7	NO	YES	YES		NO	$3132	$824
E-8	NO	YES	YES		NO	$450	$580
E-9	NO	YES	YES		NO	$450	$193
E-10	NO	YES	YES		NO	U	U
E-11	NO	YES	YES		NO	$450	$190
E-12	NO	YES		YES		$1500	$8000
E-13	NO	YES	YES		NO	U	U
E-14	NO	YES	YES		NO	$450	$876
E-15	1/2"	NO		YES		N/A	N/A
E-16	1/2"	NO		YES		N/A	N/A
E-17	1/2"	NO		YES		N/A	N/A
E-18	1/2"	NO		YES		N/A	N/A
E-19	1/2"	NO	YES		YES	N/A	N/A
E-20	1/2"	NO	YES		YES	N/A	N/A
E-21	1/2"	NO	YES		YES	N/A	N/A
E-22	1/2"	NO	YES		YES	N/A	N/A
E-23	1/2"	NO	YES		YES	N/A	N/A
E-24	1/2"	NO	YES		YES	N/A	N/A
E-25	1/2"	NO	YES		YES	N/A	N/A
E-26	1/2"	NO	YES		YES	N/A	N/A
E-27	1/2"	NO	YES		YES	N/A	N/A
E-28	1/2"	NO	YES		YES	N/A	N/A
E-29	1/2"	NO	YES		YES	N/A	N/A
E-30	1/2"	NO	YES		YES	N/A	N/A

NOTE: N/A - NOT APPLICABLE
U - UNKNOWN